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L. C. Hanson Company
Black Diamond Mine, Wibaux County, Montana

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FINAL REPORT

BLACK DIAMOND MINE
WIBAUX COUNTY, MONTANA

JULY, 1985

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L. C. HANSON COMPANY
CONSULTING ENGINEERS & SURVEYORS
HELENA — GREAT FALLS — GLENDIVE

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FINAL REPORT

BLACK DIAMOND MINE
WIBAUX COUNTY, MONTANA

JULY, 1985

ATTENTION: MR. RICHARD JUNTUNEN, CHIEF
Abandoned Mine Reclamation Bureau
Department of State Lands
1625 11th Avenue
Helena, MT 59620

PREPARED BY: L. C. HANSON COMPANY
Consulting Engineers
3108 McHugh Lane
PO Box 299
Helena, MT 59624

James E. Hodges, P.E.
Wally Koch, P.E.
Project Engineers

William F. Shaw, C.E.T.
Project Inspector

L. C. HANSON COMPANY
CONSULTING ENGINEERS & SURVEYORS
HELENA — GREAT FALLS — GLENDIVE

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BLACK DIAMOND MINE RECLAMATION

PROJECT OBJECTIVES:

The BLACK DIAMOND reclamation project was undertaken to eliminate an immediate hazard to public safety, restrain the continuing collapse of the mine along a county road and return the surface to a usable condition.

PROJECT LOCATION:

BLACK DIAMOND MINE is located in Wibaux County in Township 13 North, Range 60 East in the southeast one-quarter of Section 10 and is approximately 8 miles southeast of Wibaux.

SITE DESCRIPTION:

The site consists of 7.62 acres of grassland at two locations; the North Mine consists of 5.62 acres in the northeast corner of the southeast one-quarter section and the South Mine consists of 2 acres in the southeast corner of the same one-quarter.

Farmland surrounds both sites which are adjacent to a county road. Both sites had surface subsidence features. Those at the North Mine were most pronounced. Three of the North Mine Subsidences covered a total area of nearly 23,000 S.F. with sheer vertical walls ranging in depth from 21 feet to 28 feet. Two of these subsidences were immediately adjacent to the county road; both of these had been barricaded and partially backfilled to reduce the hazard. Public access had not been eliminated and all the subsidences were being used for refuse disposal.

The BLACK DIAMOND MINE is an abandoned shaft coal mine which used a room and pillar layout. An official mine map is not available for either the North Mine or the South Mine. Interviews with a local man indicated that the North Mine may have covered 400,000 S.F. of area and that as much as 100,000 C.Y. of coal might have been removed.

The sites are overlaid with searing loam varying in depth from several inches to a foot. Exploratory drilling showed the sites to be underlain with soft brown

sandstone, silt, siltstone and clay to a depth of 32 feet. A 30-foot seam of coal underlies these materials.

Boreholes made into the mine void indicated that mining operations removed an average of 10 feet of coal from the middle of the seam leaving 10 feet of coal in the ceiling. Construction drilling and monitoring showed the northern portions of the North Mine are apparently flooded with water to an average depth of 6 feet.

PROJECT PLANNING:

L. C. Hanson Company designed and engineered the reclamation plan for this project and was also responsible for Contract administration and on-site inspector services.

Several reclamation processes were studied. They included: remining; blasting of the pillars and overburden; hydraulic stowing; and gravity flush stowing. Gravity flush stowing was chosen as the most cost effective means of restraining the effects of continuing mine collapse on the road.

PROJECT SCOPE:

The scope of the project included underground support in an area where an active subsidence was impacting the county road. This support was to encompass only a limited area immediately adjacent to the county road. The desired effect of this support was to limit the surface features of future mine collapse to minor settlement.

In addition, the project included burial of refuse and debris; caving and backfilling subsided area to eliminate high walls; rebuilding the county road; and revegetating the construction area.

It is anticipated that further subsiding may occur since this project constituted only a partial reclamation of the subsurface conditions. For this reason, the Department of State Lands plans to periodically monitor the sites.

WORK DESCRIPTION:

The mine reclamation construction phase began July 30, 1984. The project was

substantially completed on December 5, 1984 except for revegetation, which was completed in the Spring of 1985 after a winter shut down.

The procedures designated to accomplish the reclamation objectives included:

1. Drilling boreholes to determine the subsurface condition of the mine and to monitor the stowing operation. Boreholes ranged in diameter from 5 inches to 10 inches. The larger diameter was required at stowing and well locations.

2. Construction of a water supply, disposal and storage system. This work included two water wells with submersible pumps, a sprinkler irrigation network spread over adjacent cropland and a surface containment pond. The disposal system was installed in anticipation of the need to lower the mine water level. The pond provided operating water for flooding and stowing.

3. Water flooding of loosely consolidated soil and mechanically excavating to gain access to the void spaces underlying the site.

4. Excavating, segregating and stockpiling topsoil and backfill material.

5. Gravity flush stowing backfill material into the mine voids. This operation entailed moving excavated soil to a hopper, turbulence mixing with high pressure water and flushing this slurry into the voids underlying the site. This process facilitated the placement of 19,000 C. Y. of soil within 43 days while cycling 2.2 million gallons of water through the mine.

6. Caving and backfilling subsided areas.

7. Rebuilding and resurfacing the county road.

8. Regrading the borrow site, placing topsoil and replanting the construction area.

COST AND QUANTITY SUMMARY:

The following tables show the work items, quantities and costs involved in the reclamation of the BLACK DIAMOND MINE.

TABLE I: Cost of reclamation based on unit of measure and total surface area including borrow reclamation.

		COST		
ITEM	QUANTITY	PER UNIT	TOTAL	PER ACRE
Water System: Includes: construction and operating costs for wells, pumps, irrigation network, surface pond and production system.	2.6 MGAL	$ 28.53 MGAL	$ 74,179.15	$ 9,760.43
Water Flooding: Includes: costs of laying out and moving piping and monitoring the erosive effects of the water.	400 MGAL	4.18 MGAL	1,672.60	220.00
Backfill Boreholes: Includes: material and labor for plugging boreholes into mine void and others.	935 L.F.	10.45 L.F.	9,774.60	1,286.13
Gravity Flush Stowing: Includes: costs of excavating, hauling and flushing soil into the mine void.	15,574 C.Y. (BM)	6.00 C.Y.	93,444.00	12,295.26
Subsidence Backfill: Includes: cost of excavating, hauling, placing and compacting soil in subsidence features.	8677.5 C.Y. (BM)	1.60 C.Y.	13,929.00	1,832.76
Surface Reclamation: Includes: cost of excavating, stockpiling and replacing topsoil, and reseeding all disturbed areas.	7.6 ACRES		13,099.37	1,723.60

ITEM	QUANTITY	PER UNIT	COST TOTAL	PER ACRE
Mobilization and Misc:				
			$ 32,972.34	$ 4,338.47
TOTAL			$239,070.46	$31,456.64

TABLE II: Cost of reclamation based on the estimated subsurface area that the work is estimated to have directly affected.

ITEM	AREA/DESCRIPTION	COST TOTAL	 PER UNIT
Water System: Used to flush material into the mine void.	21,500 S.F. (.494 acres) Estimated area of mine void assumed to be partially filled with stowed material.	$ 74,179.15	$ 3.45/S.F. 150,160.00/ACRE
Water Flooding: Used to create mine void accesses by eroding loose soil in areas of mine collapse.	Same as above	1,672.60	.08/S.F. 3,385.83/ACRE
Gravity Flush Stowing: Material and process used to partially fill the mine void.	Same as above	93,444.00	4.35/S.F. 189,160.00/ACRE
Subsidence Backfill: Material and process used to fill surface subsidence features.	23,000 S.F. (.528 acres) Estimated area of surface subsidence features.	13,929.00	.61/S.F. 26,380.00/ACRE
Surface Reclamation: Material and process used to reclaim the borrow source.	44,500 S.F. (1.0 acres) Estimated total of subsurface area affected.	13,099.37	.29/S.F. 13,099.36/ACRE
TOTAL PROJECT COST:	44,500.0 S.F. (1.0 acres)	$239,070.46	5.36/S.F. $239,070.46/ACRE

RESULTS OF THE STOWING OPERATION:

Gravity flush stowing was performed at a single location adjacent to the county road. The intent of this operation was to flush sufficient quantities of soil into the mine voids along the road to partially fill them; thus depressions from further mine collapse would be limited to minor surface features. To what extent the desired results were achieved remains undetermined; however, project data does permit an estimation of the area that stowing affected.

The area estimated to have been affected is depicted in Drawing #1. This estimate is based on data gathered at Borehole #45, stowing quantities reports, estimates of subsidence hole volume and estimates of the original mine layout.

MINE LAYOUT:

Estimates of the mine layout assume that the ceiling in each 900 S.F. area is supported with a 200 S.F. pillar. Thus calculated, 7/9th of the mine is void and 2/9th is pillar. When applied to material measured on the surface and placed in the mine void, the material will cover an additional 2/9th of the area.

The volume of the mine void was determined using this method and an average room height of 10 feet which was determined from construction drilling logs.

SUBSIDENCE VOLUME:

Estimates of the subsidence hole volumes indicate that nearly 19,500 C.Y. of soil had been displaced. It is assumed that water had eroded this material, carried it into the mine and dispersed it equally into all the adjacent voids. Drawing #1 depicts the estimated area of soil deposition.

Water deposited soil has a free standing slope which is dependent upon the soil particle size, weight of the soil and velocity of the displacing agent; slopes typically range from 10:1 to 50:1. Soil displaced from the BLACK DIAMOND subsidences is predominantly sandy silt (small particle size) weighing approximately 100 lbs/C.F. (light) and assumed displaced during a 20-year period (very gradual). For these reasons the slope is assumed to be closer to the higher range.

The actual slope of the soil in the mine void is unknown; the leading edge depicted in the drawing is shown as if vertical and is assumed to present a liberal outline of the mine regions partially filled with displaced material.

The assumption that surface material has been displaced into the mine void has been confirmed in the immediate vicinity of Borehole #45. Measurements there prior to commencement of stowing operations showed the mine void partially filled with sandy silt.

STOWING RECORDS:

Borehole #45 was an uncased 10 inch borehole drilled during the construction phase of the project. It was used as a monitoring station during the stowing operations. Measurements made at the borehole recorded changes in the height of the fill in the underlying void.

The data gathered at Borehole #45, in conjunction with daily reports of the estimated quantities stowed, is presented in the Borehole #45 Monitoring Report.

ESTIMATED AREA:

Drawing #1 shows Subsidences #1, #2 and #3. Depicted is the assumed location of the material displaced from the subsidences and dispersed equally to the mine void adjacent to each. Also depicted is the area of the mine assumed partially filled with stowing material.

Note the overlap of displaced material between Subsidences #2 and #3. Here it is assumed that the void is sufficiently filled to prevent the passage of large quantities of stowing material. For this reason, it is assumed that the stowing material partially filled the area between the three subsidences while passing south between Subsidences #1 and #2 and east of Subsidence #1.

It is likely that material moving directions other than south would have had a constant impact on the height of the fill at Borehole #45. The Monitoring Report shows that 3000 C.Y. between 11,000 C..Y. and 14,000 C.Y. did not change the height of the fill at Borehole #45.

The drawing depicts the affected area as nearly 36,000 S.F.. Here again,

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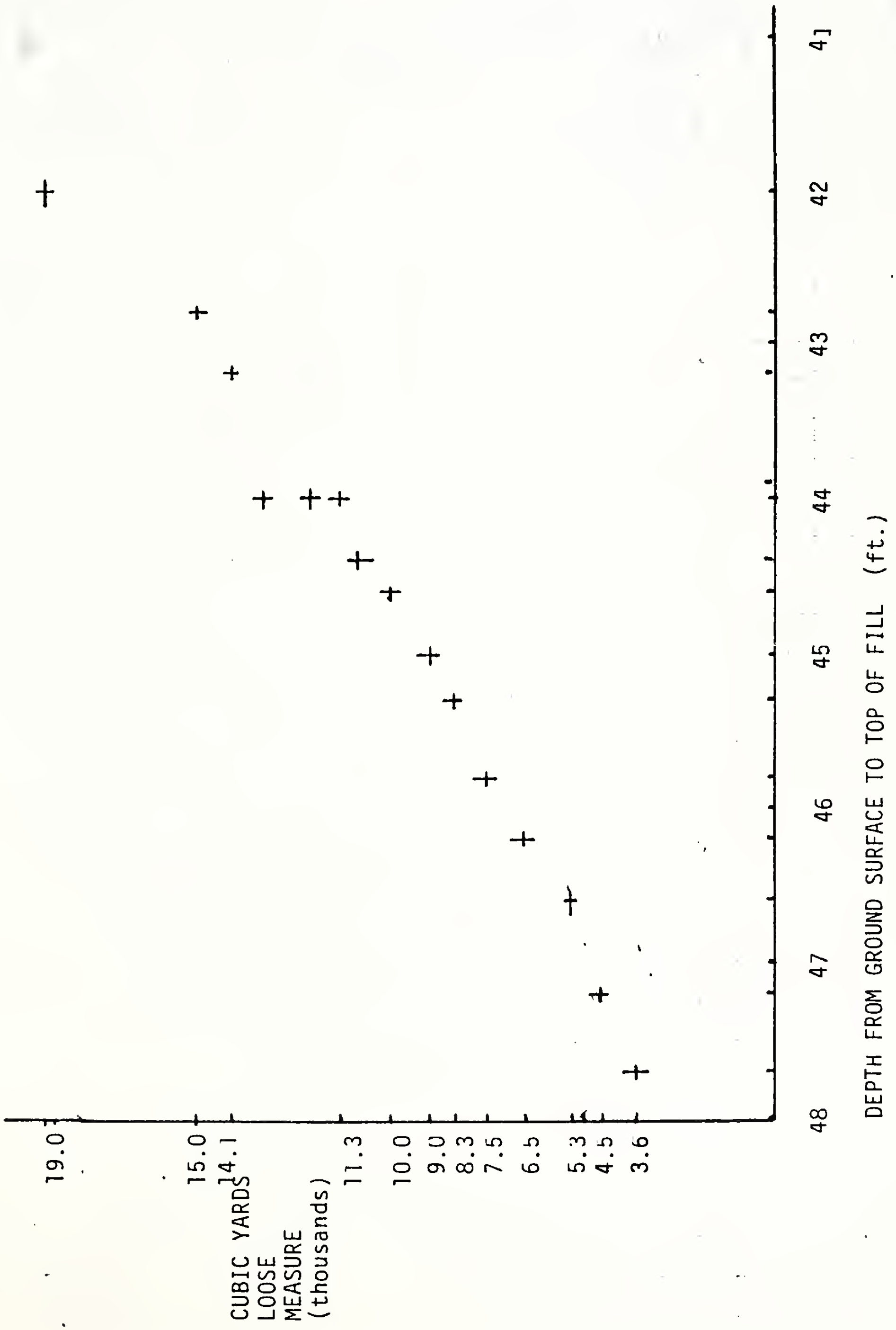
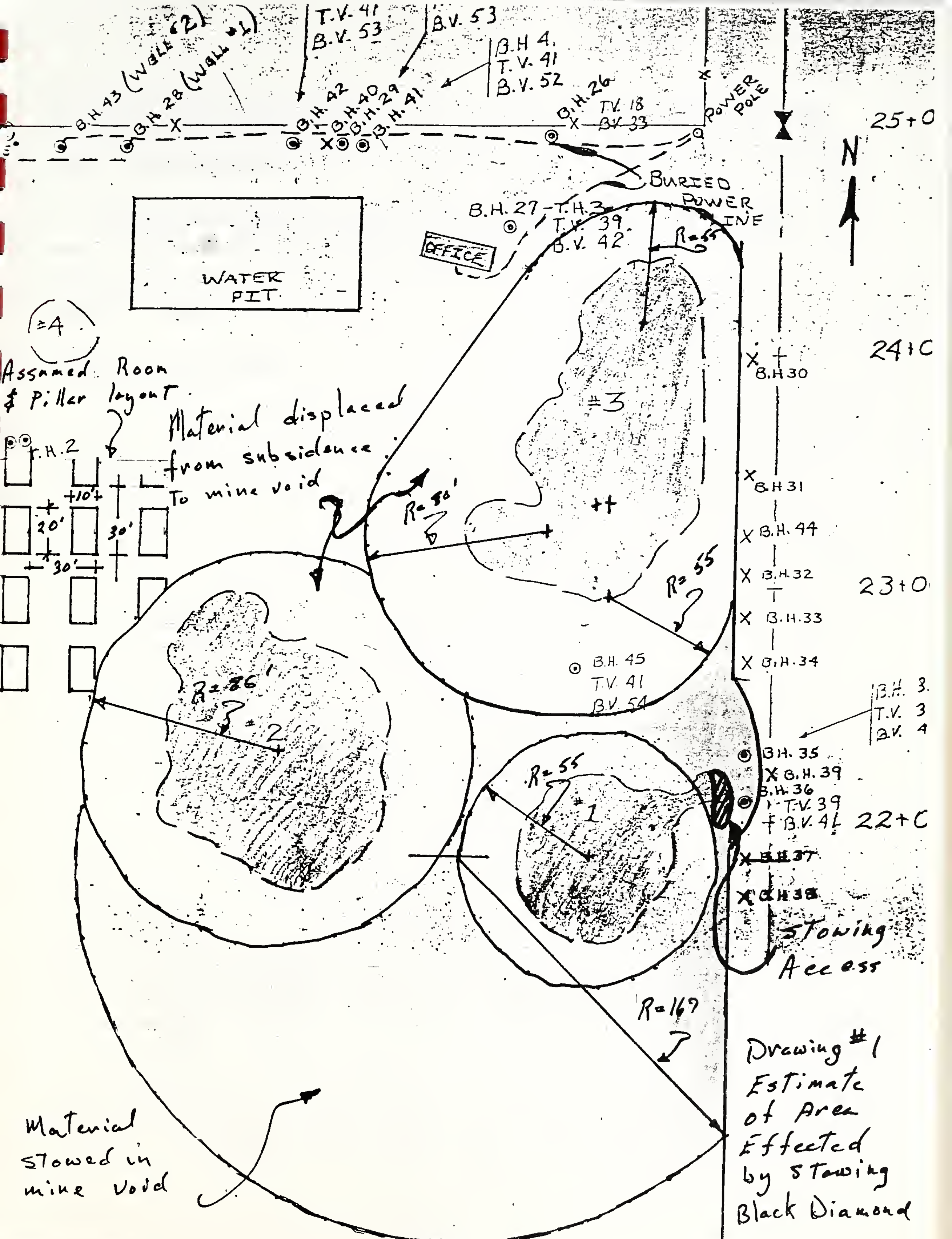
(406) 442-8108

JOB BLACK DIAMOND
SHEET NO ________ OF ________
CALCULATED BY W. F. Shaw DATE ________
CHECKED BY ________ DATE ________
SCALE ________

BOREHOLE #45 MONITORING REPORT



PRODUCT 704-1 NEBS Inc. Groton, Mass. 01471



Drawing #1
Estimate of Area Effected by Stowing Black Diamond

the leading face is shown as vertical. If the leading face is adjusted to a slope of approximately 50:1 then the area sufficiently filled to limit surface depressions may be nearer to 20,000 S.F.

In the final analysis the only area known to be sufficiently filled is that area in the immediate vicinity of Borehole #45.

ENGINEER'S COMMENTS:

STOWING AT BLACK DIAMOND

The gravity flush stowing process was particularly effective at the BLACK DIAMOND site. Chief among the factors responsible for the effectiveness of the process are the following: the availability of an adequate water supply; a low percentage of clay in the stowing material; and the high venting capacity of the stowing access.

Water is crucial to the stowing process; large quantities are necessary for forming the slurry with turbulence mixing and flushing the slurry from the hopper. A typical slurry ratio of water to soil is approximately 150 gal/C.Y. The BLACK DIAMOND project utilized more than 2 million gallons in the stowing process.

Planning phase drilling had determined that the large volume of water required in the process was present in the mine voids. The recharge rate of this reservoir was not of importance because of mine void continuity between the well location and the stowing access which permitted rapid recycling of the stowing water.

Rapid recycling did result in turbid water infiltrating the wells even though gravel pack filters were present and the wells were located more than 400 feet from the stowing access. It was a matter of great concern that the abrasive action of the fine sediment might damage the pumps, meters or nozzles. Steps taken to mitigate damage included pump shutdown when the discharge was turbid, maintenance of a large surface reserve pit and recharge of the surface reserve during periods when stowing was not being performed.

The amount of clay in the stowing material is an important factor. A high clay content necessitates a higher water-soil ratio and reduces stowing production. The clay deposits encountered at BLACK DIAMOND were not easily brought to a friable con-

dition with ordinary handling; thus, it often entered the mixing hopper in lumps, In addition, the clay had low permeability which prevented normal turbulence mixing from breaking and dispersing the clay lumps. Increased water content had some mixing benefit, but was mostly needed to flush the clay from the hopper. A large clay lump or poorly dispersed lumps would plug the outlet requiring operation shutdown and manual cleanout. Fortunately the clay content was not high enough to cause significant problems at this site.

Venting is another very important factor. During peak periods of operation, the rate that stowing material displaces mine void can exceed 100 cfm. The water or air displaced must escape through vents such as strategically placed boreholes, the stowing access or the mine voids.

Venting is especially a problem when the mine voids are filled with water. In this circumstance dewatering the mine becomes an essential part of the stowing process. In expectation of encountering this problem, BLACK DIAMOND was equipped with a dewatering system; however, it proved unnecessary because of the use of a large stowing access, adequate mine void continuity and water levels which were several feet below the mine ceiling.

PLANNING STOWING PROJECTS

The gravity flush stowing process definitely has potential application to projects where the objective is to limit the surface effects of potential mine void collapse. The design of such projects must consider water availability and water handling methods, the soil type planned for use as stowing material and the condition of the mine voids.

A water availability assessment must include estimates of quantity and determination of water quality. Estimates of water quantities required in the stowing process are based on the loose volume of the soil that will be flushed into the void. The water-soil ratio for this slurry can range around 150 gal/C.Y. for sandy soil but can be significantly greater for soils with a high clay content. Water quality is assessed in terms of discernible detrimental effects it may have on adjacent water sources or surface areas in the case of dewatering and disposal by irrigation.

The design of water handling systems must consider the effects of turbidity on mechanical portions such as pumps, meters and nozzles. Special pumps, filters and

settling ponds may be necessary components of the system depending on the type of soil used in the slurry, the proximity of the stowing access to the source of water and the rate of water recycling.

The type of soil available for stowing must be determined early in the planning phase. A gravity flush stowing project based on soils having some clay content should consider special handling of the material. Soils with even small amounts of clay should be excavated in a manner that assures thorough mixing with sandy soils and delivered to the hopper in a friable condition. Projects using soils with a high clay content should consider using mechanical mixing equipment in the hopper in addition to normal turbulence mixing. Practice has shown that an acceptable range for clay content is 5% to 50% of the dry mix.

Information concerning the condition of the mine void is important in both the planning phase and the construction phase. Exploratory drilling is necessary to determine mine void continuity, void water levels and subsurface soil conditions. The condition of the mine void will determine the type of stowing access that is most productive and the type of venting that must be provided.

Stowing accesses in areas adjacent to surface subsidence features may best be achieved with excavation at the rim of the subsidence. The objective of excavating at this location is to intercept the ceiling of a progressing collapse. The equipment required for this work must have sufficient reach to assure access to the voids. The advantage of this type of access lay in its ability to handle large volumes of stowing material while also providing an adequate vent.

Stowing into drilled holes will require planning of borehole diameter and borehole spacing. Factors involved in this planning include the flowability of the slurry and the anticipated venting requirements. High-quality, well-mixed slurry can be successfully stowed using 8-inch ducts and 10-inch boreholes. Slurry of this quality can be expected to travel 100-feet or more, thus requiring fewer boreholes. Using larger boreholes and relying on back venting around the stowing ducts may achieve the required venting; however, as the void fills, offset boreholes will be more effective.

In some respects this process remains uncommon and requires special attention to certain details, such as those previously discussed. This attention must also

be evident in the wording and performance of the Contract.

One such detail is the method of measurement for stowing material. It is very important that the Contract fully describe the method of measurement and designate a schedule of measurement. Great attention must be given to this detail because compensation for stowing material is usually substantially higher than material used in other work items, though it may be the same material and frequently from the same borrow source. One method of controlling this material is to designate a specific borrow source for a specific work item. Another method would require the completion of a particular item of work and measurement of the material used prior to commencing work on other items.

Other details include descriptions of work procedures. These must be carefully described, especially when the work involves special equipment and methods. This may be construed as directing the Contractor's operation to the extent that he is presented with a well defined method and a logical sequence for accomplishing the project goals. This also remains the best means of assuring that the Contractor is thoroughly familiar with the project requirements and bases his bid accordingly.

The level of competency of the Contractor when working under actual site conditions is a factor which can only be evaluated by actual performance. It is, therefore, imperative that the apparent low bidder demonstrate his equipment and technique before the Contract is awarded. Even a process as apparently simple as gravity flush stowing is a problem for some Contractors.

INSPECTOR'S COMMENTS:

As the Owner's on-site representative during the entire construction phase of the BLACK DIAMOND reclamation, I believe that the project objectives have been accomplished. The good success encountered with the stowing process placed sufficient material in the void along the county road to assure that any future settlement in the area immediately adjacent to the road will result in only minor surface depressions. All known hazards have been either reclaimed or barricaded and scheduled for reclamation during the 1985 construction season.

- PHOTO LOG -

SHEET A

1A - 4A	Stowing hopper. Sloping sides, bottom cleanout 8" discharge, sidewall nozzles, plumbing for side nozzles and nozzle mounted at head of discharge chute
5A	Production pump for stowing hopper
6A	Stockpiling stowing material
7A - 8A	Moving stowing material to hopper from stockpile
9A - 10A	Loading hopper
11A - 14A	Flushing soil from hopper after turbulent mixing
15A	View south of stowing and topsoil stockpiles
16A	Surface containment pond
17A	Debris in subsidence
18A	Subsidence 21 feet deep
19A - 20A	Backhoe excavation for mine void access

- PHOTO LOG -

SHEET B

1B	Surface containment pond
2B	Wells #1 and #2, well control panels, meter house and discharge to pond
3B - 4B	Meter house and meter
5B	Well #2 and lateral to meter house
6B	Discharge and cleanout for irrigation system
7B - 9B	Irrigation system layout
10B - 19B	Flooding subsidences to gain mine void access

BLACK DIAMOND MINE PHASE II
WIBAUX COUNTY, MONTANA

- PHOTO LOG -

SHEET C

1C - 5C	Preparation for topsoil placement
6C	Control point indicating the original ground elevation prior to construction
7C - 10C	Topsoil placement
11C	Barricading subsidence that will be completed in later operations
12C - 13C	Storage of irrigation system
14C - 16C	Stockpile during construction

BLACK DIAMOND MINE PHASE II
WIBAUX COUNTY, MONTANA

- PHOTO LOG -

SHEET D

1D - 2D	Preparing to seed and fertilize
3D - 5D	Site after seeding
6D - 16D	Applying mulch and tracking mulch
17D	Permanent installation of sign
18D	Concrete culvert installed

BLACK DIAMOND MINE PHASE II
WIBAUX COUNTY, MONTANA

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BLACK DIAMOND PHASE II
WIBAUX COUNTY, MONTANA

JULY, 1985

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1625 11th Avenue
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CONSULTING ENGINEERS & SURVEYORS
HELENA — GREAT FALLS — GLENDIVE

BLACK DIAMOND PHASE II

PROJECT OBJECTIVE:

The BLACK DIAMOND PHASE II reclamation project was undertaken to conclude mine-related problems which became apparent during Phase I construction operations. These were considered a hazard to public safety.

PROJECT LOCATION:

The BLACK DIAMOND MINE is located in Wibaux County in Township 13 North, Range 60 East in the Southeast one-quarter of Section 10. It is approximately 8 miles southeast of Wibaux, Montana.

SITE DESCRIPTION:

The site included approximately 2 acres, consisting of .2 acres of farmland north of the Phase I site and 1.8 acres along the northern border of Phase I. Most of the site had been used as a borrow source for Phase I and had been partially reclaimed with the placement of topsoil.

Two subsidences remained from the conclusion of Phase I due to a shortage of on-site borrow. One had been partially backfilled and the other was barricaded with wire. An air shaft, discovered during Phase I borrow operations, was also barricaded with wire.

PROJECT PLANNING:

L. C. Hanson Company designed and engineered the reclamation plan for this project which was approved by the Montana Department of State Lands. L. C. Hanson Company was also responsible for Contract administration and on-site inspection services.

Preliminary engineering was performed using data gathered during exploratory drilling performed in October 1984 and January 1985 and information gleaned from operations performed in Phase I.

Phase I operations indicated that portions of the mine void were flooded and

that the largest volume of this water underlayed the area of Phase II. Phase I operations had also shown that the subsoil was easily eroded with water. Phase I borrow operations exposed an air shaft at a previously unknown location. Phase I drilling located an incipient subsidence within 18 feet of the surface in the northeast corner of the Phase I site.

The October exploratory drilling located the mine void north of the Phase I site and identified an incipient subsidence in this area.

The drilling in January confirmed the perimeter of the northeast incipient.

PROJECT SCOPE:

The scope of the project included: providing coarse and fine backfill material and water for flooding and compacting the backfill; backfilling two subsidence holes; gaining access to an incipient subsidence and backfilling the underlying void; closing an air shaft; casing boreholes for future monitoring; backfilling other boreholes; salvaging and replacing topsoil; and re-establishing vegetation on the site.

WORK DESCRIPTION:

May 15, 1985 the Department of State Lands issued a Notice to Proceed to Jarrett Construction, Inc. of Miles City, MT. A preconstruction conference was held on site on May 29, 1985.

Immediately after the conference the Contractor commenced work. The project was substantially completed on June 10, 1985, except for revegetation which will be completed after October 15, 1985.

The Contractor removed the wire barricades from the subsidence hole and air shaft and a portion of an existing farm fence located over the northeast incipient. The wire was disposed in the subsidence.

The Contractor used a 1 C.Y. track-mounted backhoe to excavate the overburden at the incipient. This exposed a sandstone reef which covered the majority of the void. Though the plan had designated blasting the reef, the Contractor was given permission to break the reef using this backhoe. The Contractor's operation

exposed the entire void.

After the void was exposed, a ramp was constructed into the subsidence and a dozer used to spread and compact moisture conditioned fill material. Final fill and compaction were accomplished using a scraper.

The air shaft and the deeper subsidence received a base fill of scoria. This coarse material was flooded and covered with three-foot lifts of fine material, which was saturated to achieve compaction. The final three feet were installed in one-foot lifts, moisture conditioned, and compacted with a dozer.

The shallow subsidence was backfilled in one-foot lifts, moisture conditioned, and compacted with the scraper.

Eight (8) boreholes into the mine void were filled using pipestands and concrete. Five (5) boreholes into the void were cased rising four-inch PVC with a concrete collar.

After the conclusion of these operations, topsoil was placed on all work areas and the farm fence was reconstructed.

COST AND QUANTITY SUMMARY:

The table below shows the work item, quantities, and costs involved in the Phase II reclamation of the BLACK DIAMOND MINE.

ITEM	QUANTITY	COST PER UNIT	TOTAL	PER ACRE
Provide Fine Backfill: Includes: borrow source development and site delivery.	1820 C.Y.	$ 4.00	$ 7,280.00	$ 3,640.00
Provide Coarse Backfill: Includes: acquisition and site delivery.	133 C.Y.	10.00	1,330.00	665.00
Provide Water: Includes: piping, power and delivery to work items.	52 MGAL	50.00	2,600.00	1,300.00
Fill Borehole: Includes: material and labor	8 UNITS	100.00	800.00	400.00
Case Borehole: Includes: material and labor	5 UNITS	300.00	1,500.00	750.00
Backfill Subsidence: Includes: equipment and labor for placing material	LUMP SUM		14,000.00	7,000.00
Backfill Shaft: Includes: equipment and labor for placing material	LUMP SUM		700.00	350.00
Miscellaneous: Includes: mobilization, constructing fence, reinstalling power line and constructing channel	LUMP SUM		4,300.00	2,150.00
Seed, Fertilize, Mulch: Includes: Material, equipment and labor	2 ACRES		2,330.00	1,165.00
TOTAL			$34,840.00	$17,420.00

ENGINEER'S COMMENTS:

Phase II of the BLACK DIAMOND MINE reclamation accomplished its objectives. Open subsidences remaining from Phase I, an air shaft and an incipient subsidence were successfully backfilled. All discernible hazards to public safety were either reclaimed or made accessible to monitoring.

The Use of Coarse Backfill: Phase I of this project was a gravity flush stowing operation which placed approximately 15,000 C.Y. of soil in the mine void adjacent to the county road along 500 feet of the eastern border of the Phase I site. The Phase I wells supplied nearly 2,000,000 gallons of water which were recycled through the mine. These wells were located adjacent to the deeper of the two subsidences and the air shaft. These work items had continuity with the mine void.

For these reasons it was assumed that both were underlayed with saturated unstable material. To limit the possibility that this material would fail under the load of nearly 40 feet of backfill, the plan designated that these work items be backfilled to one-half their depth with coarse material -- scoria was used because it was locally available. Flooding of the coarse material was designated to aid bedding the stone into the mine floor mud.

The Incipient Subsidences: Two incipient subsidences were located at BLACK DIAMOND. The incipient in the northeast corner of the site was discovered during Phase I drilling. The incipient north of the Phase I site was identified during exploratory drilling.

Additional drilling was performed at the northeast incipient in 1985. These boreholes permitted the use of a down hole camera, which confirmed the extent of the collapse. The incipient void underlayed nearly 900 S.F. of area with only 18 feet of overburden remaining. For these reasons and the fact that it was adjacent to the county road, this incipient was scheduled for reclamation in Phase II.

Drilling had shown the void partially covered with a sandstone reef which varied in thickness from 1 foot to 6 feet. The presence of the reef required the analysis of several methods of backfill. Among these were: excavating perimeter access points or drilling boreholes and pneumatically stowing backfill; and blasting

the capstone and collapsing the overburden. Blasting proved to be the most economical and was designated in the plan.

Blasting was not used, instead the Contractor successfully collapsed the capstone using a backhoe; however, the Contractor reported this method damaging to the equipment.

Borehole logs from drilling north of the site showed the void in this area partially filled with water. To determine the extent of the mine, sonar equipment was used.

The logs and sonar reports indicated that the incipient was occurring along the end of the mine which may retard its progress. For this reason and because the incipient was in a region away from the county road and under a conspicuously uncultivated area, this incipient was not reclaimed in Phase II. Vicinity boreholes into the void were cased to allow future monitoring of this incipient and the adjacent area.

The Landowners: The site Landowners were cooperative and helpful. They provided an off-site borrow source for fine backfill material and permitted the installation of monitoring stations in the midst of their cropland.

Respectfully submitted,

William F. Shaw, C.E.T.
Field Inspector